8-1-1982

What Soil Erosion Means to Land Productivity

J. V. Mannering
D. P. Frazmeier
G. C. Steinhardt
What Soil Erosion Means to Land Productivity

J. V. Mannering, D. P. Franzmeier and G. C. Steinhardt, Department of Agronomy, Purdue University

Excessive soil erosion and its effects on water quality have received much attention over the last decade. Lately, however, there has been renewed public and government interest concerning the influence of soil erosion on land productivity. A recent national opinion poll indicated that over 50 percent of those surveyed felt soil erosion was a major problem in this country. This concern is substantiated by a resource status inventory, mandated by the Soil and Water Resources Conservation Act of 1977 (RCA), that showed significant present and potential land productivity losses due to soil erosion.

Indiana is certainly not immune from soil loss problems. Approximately 4,000,000 acres (almost a third of the state’s total cropland) is sloping, thus subject to serious erosion if not properly managed. The RCA inventory estimated the average soil loss from this sloping cropland acreage under present land use to be as follows:

It should also be pointed out that (1) many soils are eroding at rates greatly in excess of the above averages, and (2) these soil losses are at rates much greater than the rate at which new soils are being formed from parent materials, such as bedrock, glacial till or loess.

How Most Indiana Cropland Soils Were Formed

Some soil parent materials, such as loess (deep deposits of wind-blown silts) or alluvium (stream-deposited sediments), are relatively “loose” and have low bulk densities. Other parent materials, such as glacial till (once pressed under thousands of feet of ice), old weathered soils and heavy lake sediments are “tight” and have high bulk densities.

Most sloping Indiana soils have between 10 to 40 inches of loose soil material over tight material. The loose material is better for plant growth; it stores

Excessive erosion reduces productivity.

<table>
<thead>
<tr>
<th>Slope range</th>
<th>Average annual soil loss</th>
<th>Time to remove 7-inch plow layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-6 percent</td>
<td>7 1/2 tons/acre</td>
<td>133 years</td>
</tr>
<tr>
<td>6-12 percent</td>
<td>11 tons/acre</td>
<td>91 years</td>
</tr>
<tr>
<td>12-18 percent</td>
<td>29 tons/acre</td>
<td>34 years</td>
</tr>
</tbody>
</table>
water efficiently, and roots can penetrate it easily to use the water. The tight material is just the opposite; it has few pores that store water, making root penetration difficult.

With time, several changes are likely to occur through soil formation.

1. The tight material is formed into natural aggregates or "peds," usually measuring from less than one inch to a few inches across. Water runs through cracks between the peds. Roots can grow along these cracks but do not easily penetrate into the peds.

2. The loose material, especially loess, becomes cemented together into a fragipan—a dense, brittle subsoil horizon that retards water and root penetration.

3. Subsoil layers in both loose and tight materials become more acid and produce enough aluminum compounds to retard root growth.

The first change produces a better rooting medium, while the other two produce poorer soil material. The rate at which these changes occur, however, is extremely slow—probably around 1-2 inches per thousand years.

In many of our Indiana soils, there is a good rooting medium over a poorer one. Meanwhile, the subsoil materials may be changing from poor to good, or vice versa. But over a 100-year period (a long time relative to farming history, but a short time relative to soil formation), any such change is negligible. In other words, we have a certain amount of good soil to work with, and that's it! So what we have we must conserve.

**What Excessive Erosion Does to the Soil**

Soil erosion caused by water occurs from the surface downward. In time, it reduces the soil depth suitable for seed germination and crop rooting, even to the point where subsoil is exposed. That can be particularly serious on shallow soils overlying bedrock or unfavorable subsoil conditions.

Excessive erosion often increases the clay content of the surface soils by mixing in more clayey subsoils during plowing. This results in poorer structure, more rapid sealing and decreased infiltration of water. The soil stores less moisture for crop use and becomes more droughty.

Erosion is also a selective process, removing the fines (silt and clay) and the organic matter at a more rapid rate than the coarser sand fraction. This can result in poorer soil tilth and lower soil nutrient- and water-holding capacity. In addition, the clay and organic matter lost through erosion removes fertilizer nutrients with it, thus reducing the overall fertility of the soil.

Severe erosion is a condition where much of the topsoil has washed away, and now the top 7 inches contains more subsoil than topsoil or is all subsoil. Severe erosion normally results from years of improper management and abuse of the land. To restore such land will take many, many years, if, in fact, it can ever be restored.

**How Crop Yields Are Affected by Excessive Erosion**

The extent of crop yield reduction due to soil erosion will vary widely. It depends on a combination of factors including: (1) the severity of the erosion, (2) the soil properties such as depth, texture, structure, and nutrient-supplying power of both surface and subsoils, and (3) the ability of a particular crop to root effectively in the subsoil. Extreme conditions range from almost total inability to produce crops (as would be the case with severe erosion on a shallow soil, exposing large areas of bedrock) to little, if any, crop yield reduction (as with severe erosion on heavily fertilized, deep silt soil).

Following are brief summaries of three research efforts to determine the magnitude of yield loss that might occur under differing soil conditions, degrees of erosion and crops grown. The yield reduction figures reported can serve as guidelines in assessing the possible economic impact of past severe erosion on land productivity. They can also serve to "red flag" any areas on your farm that need additional conservation practices to maintain and/or improve land productivity for future generations.

1. Indiana soil scientists have attempted to estimate percent yield reductions resulting from severe erosion on the basis of major soil properties. They made these yield reduction estimates for all well- and moderately well-drained soils occurring on more than 2 percent slope.

   Expected yield reductions from severe erosion on soils of similar permeability and texture are shown in Table 2. Percent reduction for each identified soil type in Indiana is given in Purdue Extension Publication AY-212, "Indiana Soil Series and Their Properties," available from county Cooperative Extension Service offices.

2. Illinois workers have also estimated the influence of erosion on crop yields. They compared the effects under three levels of erosion—un ero ded (no mixing of surface soils and subsoils in the plow layer), moderate erosion (some subsoil mixed into the plow layer) and severe erosion (plow layer predominantly subsoil). A portion of their findings is shown in Table 3.
Table 2. Yield Reduction from Severe Erosion on Similar Indiana Soils.

<table>
<thead>
<tr>
<th>Soil groups by similar properties</th>
<th>Reduction in yield from severe erosion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Sloping, deep, porous soils developed on loess and on silts and fine sand.</td>
<td>10 percent</td>
</tr>
<tr>
<td>(Examples: Alford silt loam in southwestern Indiana, and Martinsville silt loam in central Indiana.)</td>
<td></td>
</tr>
<tr>
<td>2. Sloping, moderately permeable soils. (Example: Miami silt loam in north central Indiana.)</td>
<td>15 percent</td>
</tr>
<tr>
<td>3. Sloping, slowly permeable soils with clayey subsoils or fragipans. (Examples: Clayey silt—Morley silt loam in northeastern Indiana; Fragipan—Cincinnati silt loam in southeastern Indiana.)</td>
<td>20 percent</td>
</tr>
</tbody>
</table>

Table 3. Yield Reductions from Erosion Under Basic Levels of Management.*

<table>
<thead>
<tr>
<th>Soil group</th>
<th>Reduction under moderate erosion</th>
<th>Reduction under severe erosion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Favorable subsoil</td>
<td>5 percent</td>
<td>15 percent</td>
</tr>
<tr>
<td>Unfavorable subsoil</td>
<td>10 percent</td>
<td>25 percent</td>
</tr>
</tbody>
</table>


3. Research done in the humid eastern U.S. indicates that grain yields will decline 30-40 percent and forage yields 20-30 percent when all of the topsoil is eroded away. (See the March-April 1981 issue of the Journal of Soil and Water Conservation.)

**Implications and Actions for You the Farmer**

Increased use of fertilizers, more efficient crop varieties, better drainage, irrigation, conservation tillage and other cultural practices, pest control, etc. have done much to offset the loss of soil productivity resulting from excessive erosion. Otherwise, Indiana would be experiencing lower rather than higher average crop yields.

At the same time, we are unfortunately seeing more and larger “bare knobs” on too many of our sloping fields during stress years. This is grim warning that advances in production technology are still losing ground to excessive soil erosion.

It is important that every Hoosier farmer understand the seriousness of unchecked soil erosion, recognize the extent of the problem on his farm and apply the appropriate conservation measures to reverse the trend. Severe erosion didn’t occur just yesterday, so it will take many years of good management to restore original productivity levels.

There are many conservation practices you can use to aid restoration of eroded areas and to prevent further erosion. Included are conservation tillage, crop rotations, winter cover crops, terracing, contouring and associated structural measures, such as waterways and grade control structures. Technical assistance and additional information for reducing soil erosion on your farm is available from your county Soil and Water Conservation District, Extension Service and Agricultural Stabilization & Conservation Service offices. It is crucial that we manage our more fragile soils in a way that will retain or improve their productivity.
Cooperative Extension Work in Agriculture and Home Economics, State of Indiana, Purdue University and U. S. Department of Agriculture Cooperating. H. G. Diesslin, Director, West Lafayette, IN. Issued in furtherance of the Acts of May 8 and June 30, 1914. It is the policy of the Cooperative Extension Service of Purdue University that all persons shall have equal opportunity and access to its programs and facilities without regard to race, color, sex, religion, national origin, age or handicap.